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Near Infrared Spectroscopy and Fecal Chemistry as Predictors of the Diet Composition of White-Tailed Deer

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Abstract

Overbrowsing by white-tailed deer (*Odocoileus virginianus* Zimmermann) on Anticosti Island (Canada) created a need to develop efficient methods for estimating their foraging patterns. We tested the ability of near infrared (NIR) spectra of feces and of fecal chemical properties to predict diet composition of different individuals. We first used a principal component-based discriminant analysis to sort the NIR spectra of fecal samples ($n=102$) obtained from two groups of captive deer that had been fed two different diets. The diets differed only in their relative abundance of balsam fir (*Abies balsamea* [L.] P.Mill.) and white spruce (*Picea glauca* [Moench] Voss.) foliage. The calibrated model allowed us to assign 28 of 30 validation fecal samples (93.3 %) to the correct diet. In a second study, we attempted to estimate the proportion of coniferous, deciduous, herbaceous, and lichenous forages in diets of free-ranging white-tailed deer, as determined by fecal microhistology. Both NIR spectra and chemical properties of feces were used as predictors of diet composition. NIR spectra were analyzed using partial least-squares regression (PLSR), whereas fecal chemical properties were analyzed using mixed-linear regressions (MLRs). The PLSR models were robust ($R^2=0.89$; ratio of prediction to deviation=3.2) for predicting the amount of coniferous fragments, but not for predicting the relative amounts of balsam fir, white spruce, and deciduous and lichenous fragments within feces. MLR models revealed a positive relationship (47% variance explained) between acid detergent lignin (ADL) and coniferous fragments within feces. ADL and cellulose explained 24% of variance in deciduous fecal fragments, whereas ADL alone explained 22% of variance in balsam fir fecal fragments. These results suggest that NIR spectroscopy and fecal chemical properties have several applications on Anticosti Island, such as measuring the degree of variation in diets within a given home range or determining dietary conifer intake during winter.

Key Words: diet quality, fecal analysis, fecal microhistology, near infrared spectroscopy, overbrowsing, white-tailed deer

INTRODUCTION

Studying the foraging behavior of large wild herbivores in heterogeneous landscapes informs us on habitat selection, seasonal movements, or the impacts of herbivory on plant communities. To this end, a variety of methods have been developed over past decades to describe the diet of wild herbivores. These include fecal analyses (Stewart 1967), the probing of stomach contents (McInnis et al. 1983), browse surveys (Shipley et al. 1998), behavioral observations in the field (Parker et al. 1999), as well as isotope fractionation of animal tissues (Dalerum and Angerbjörn 2005). Among these techniques, fecal analyses are an interesting option because fecal samples are easy to obtain in high-density populations and do not require the handling or killing of animals. The main disadvantage of this approach is that highly digestible plant species could be underrepresented in the estimated diets, whereas less digestible plants could be overrepresented. Nevertheless, Hanley and McKendrick (1985) showed 65% to 77% similarity between the estimated plant species composition of rumen contents and fecal samples of Sitka black-tailed deer (*Odocoileus hemionus sitkensis* Rafinesque).

Estimating the diets of large herbivores through fecal analyses usually entails the microhistological analysis of plant fragments (Dearden et al. 1975; Lefort 2002). This method is, however, expensive and time consuming, and it requires a good knowledge of the micromorphology of different plant tissues. More rapid proxy methods have been developed, such as determining fecal n-alkanes (Bugalho et al. 2004; Dove and Mayes 2005) or DNA barcoding of plant fragments within feces (Valentini et al. 2009a), but these remain relatively expensive, and their ability to accurately quantify the proportion of different plant species in complex diets is uncertain (Bugalho et al. 2002; Valentini et al. 2009b). There is, therefore, a need to develop rapid and cost-efficient ways for estimating the diets of large herbivores through fecal analyses.

Recent research has shown that near infrared spectroscopy (NIRS) of fecal samples could be used to assess the dietary composition of free-ranging domestic livestock (Landau et al. 2006; Dixon and Coates 2009; Walker et al. 2010). NIRS is a nondestructive procedure requiring minimal sample preparation, and it produces a spectrum expressing the entire chemical makeup of the sample. NIRS may thus be used to predict both the chemical (Malley et al. 2002; Stuth et al. 2003) and

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